

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Library Philosophy and Practice (e-journal)

Libraries at University of Nebraska-Lincoln

Winter 12-12-2019

Bibliometric analysis of Indian contribution in the research literature on artificial intelligence: a study

Dr. Kumaran Marimuthu

Rathnavel Subramaniam College of Arts and Science, Sulur, Coimbatore, m.kumaran.m@gmail.com

Dr. M. Tamizhchelvan

Gandhigram Rural Institute (Deemed to be University), Gandhigram – 624 302, Dindigul, Tamil Nadu, India, tamizhchelvan@gmail.com

Follow this and additional works at: <https://digitalcommons.unl.edu/libphilprac>



Part of the [Information Literacy Commons](#), [Scholarly Communication Commons](#), and the [Scholarly Publishing Commons](#)

Marimuthu, Dr. Kumaran and Tamizhchelvan, Dr. M., "Bibliometric analysis of Indian contribution in the research literature on artificial intelligence: a study" (2019). *Library Philosophy and Practice (e-journal)*. 3756.

<https://digitalcommons.unl.edu/libphilprac/3756>

Bibliometric analysis of Indian contribution in the research literature on artificial intelligence: a study

Dr. M. Kumaran^a and Dr. M. Tamizhchelvan^b

^aRathnavel Subramaniam College of arts and Science, Sulur, Coimbatore-641 402, Tamil Nadu, India.

^bGandhigram Rural Institute (Deemed to be University), Gandhigram – 624 302, Dindigul, Tamil Nadu, India.

Corresponding Author: Dr. M. Kumaran

Chief Librarian

Srimathi Pathmavathi Memorial Central Library

Rathnavel Subramaniam College of arts and Science,

Sulur, Coimbatore-641 402, Tamil Nadu, India

m.kumaran.m@gmail.com

Mobile No: +91 9944557098

Abstract

The present research paper pertains to the bibliometric analysis of literature on Artificial Intelligence during the year 1986-2015. The main objectives of the research work are to explore the academic research/review publication contributed by the Scientists and Subject experts from the Engineering background. The data/information used in this study has been proclaimed from the online database “Scopus”. The following terms were used as keywords to retrieve the data from the “Scopus” are (TITLE-ABS-KEY-AUTH (artificial intelligence) AND PUBYEAR > 1985 AND PUBYEAR < 2015 AND (LIMIT-TO (SUBJAREA, "ENGI"))). The study has revealed and discussed on the major parameters of yearly publication, citation pattern, a bibliographic form of publication, highly contributed authors, top-ranking authors, etc. The foremost results of our study have found that during the study period 2676 research publications were contributed by the Indian authors in the Engineering discipline.

Key words: Bibliometrics; Artificial Intelligence; Citation Pattern; Scopus Database; Indian Contribution.

Introduction

Artificial Intelligence (AI) is playing a vital role in the fourth Industrial revolution and bringing a lot of machine learning methodologies. It is the recent and advanced branches of study in computer science to build smart machines to handle and perform difficult tasks with the sense of human intelligence (Shukla *et al.*, 2019). AI is an interdisciplinary science with multiple approaches, but the advancements of technology and other facilities, there are machine learning and deep learning are creating a paradigm shift in virtually every sector of the technology in the industrial world (Zhang *et al.*, 2019). So, there are evident from the fact that the literatures on Artificial Intelligence are being published across the World and the same are being covered in Primary and Secondary Sources of information (Chiarello *et al.*, 2019). The published literature on Artificial Intelligence has been analyzed quantitatively by using various Scientometric / Bibliometric indicators and other statistical techniques (Gagolewski *et al.*, 2019). The literature on Artificial Intelligence indexed in Scopus Bibliographic database has been taken up for the quantitative analysis.

Review of Literature

Shrivsyastava and Mahajan, (2016) have experimented on research output of India in the field of Artificial Intelligence by adopting Scientometric analysis methods. The major findings of their research has resulted that Information Technology has played a role in the field of Artificial Intelligence. The results of his study have revealed that number of research publications has been considerably increased and the average number of citations per paper in the study period is 3.06.

Gupta and Dhawan, (2018) have stated that output of AI based on the data retrieved from the “Scopus” during the period of 2007-2016. The study has resulted that about 10 countries in the world has contributed around 72% of AI publications. Among them India has accounted 24 highly cited research publications with the average citation of 162.46.

Tran et al. (2019) have studied the global development of scientific publications and constructed interdisciplinary research topics on the theory and practice of AI in medicine from 1977 to 2018.

West et al. (2019) have analyzed the global leader in the field of AI research publication and found that China has been published over 20% of research publications in the area of AI and

more specifically contributed in the subject field of neuroradiology, body, chest and nuclear medicine.

Zhou et al., (2019) has highlighted the important technologies that might be contribute to the structural deepening of technological recombinations and their study has concluded that the cooperative and competitive relationships among these AI technologies has improved the opportunities for future innovation through technological recombinations.

Methodology

Scopus Database

Scopus is multidisciplinary database indexing more than 15000 International peer reviewed journals in the field of Science and Technology apart from that it covers over 500 International Conference/Seminar proceedings. The modified protocol of Hinojo-Lucena et al. (2019) was adopted to carry out the present study. The following search string has been used to download the data from the database from the year 1986 to 2015:

(TITLE-ABS-KEY-AUTH (artificial intelligence) AND PUBYEAR > 1985 AND PUBYEAR < 2015 AND (LIMIT-TO (SUBJAREA,"ENGI"))))

Quantum of Research Outputs on Artificial Intelligence

The quantum of Artificial Intelligence research productivity has been analyzed as follows:

- Country wise Distribution
- Year wise Distributions Indian contribution
- Comparative Study on Yearly Distribution with Ratio of Growth
- Citation Pattern
- Bibliographic form of Publication
- Top 10 Authors

Result and Discussion

Country Wise Distribution by Year

The Yearly publication productivity on Artificial Intelligence literature by the top ten major contributors has been analyzed and the data has been depicted in **Table. 1**.

Table. 1. Country wise Distribution by Year

Year	Top10 Countries											Total
	USA	China	UK	India	Japan	Canada	Germany	Spain	Italy	France	Others	
1986	1272	27	103	8	75	64	8	4	34	59	592	2246
1987	1329	27	114	8	76	98	12	8	29	61	591	2353
1988	1213	67	78	23	132	92	31	11	40	50	493	2230
1989	1217	26	115	19	140	86	57	16	58	50	568	2352
1990	653	19	80	11	42	43	17	4	24	36	290	1219
1991	384	19	50	5	42	26	20	6	14	36	316	918
1992	416	13	46	4	51	25	20	4	23	18	285	905
1993	377	57	58	9	72	46	32	14	23	42	355	1085
1994	352	36	129	6	83	57	56	17	34	58	424	1252
1995	312	81	104	14	70	45	33	16	19	40	348	1082
1996	295	62	113	25	60	36	28	17	30	35	391	1092
1997	347	68	135	14	75	55	45	22	30	35	378	1204
1998	323	93	94	7	64	47	48	15	45	34	360	1130
1999	295	46	109	14	131	42	48	28	39	45	353	1150
2000	334	93	104	14	74	47	52	28	40	29	378	1193
2001	228	127	97	13	51	42	27	23	35	25	372	1040
2002	236	144	87	12	47	47	37	33	39	30	311	1023
2003	264	152	122	20	62	47	33	40	39	52	474	1305
2004	709	394	149	43	115	98	93	81	86	72	859	2699
2005	823	302	171	54	86	113	104	50	102	68	951	2824
2006	806	379	205	67	109	160	96	100	84	94	1183	3283
2007	840	568	204	63	112	148	112	78	115	108	1529	3877
2008	793	1613	181	75	116	160	120	215	112	79	1734	5198
2009	408	486	109	61	35	70	55	68	77	46	812	2227
2010	507	532	85	225	70	112	88	114	71	54	928	2786
2011	492	452	99	111	57	98	73	88	45	37	900	2452
2012	433	1251	91	114	51	82	71	108	67	59	1003	3330
2013	520	640	117	263	80	73	87	134	70	71	1239	3294
2014	616	818	136	467	97	82	106	214	116	81	1635	4368
2015	903	727	172	907	122	152	156	199	115	115	2173	5741
Total	17697	9319	3457	2676	2397	2293	1765	1755	1655	1619	22225	66858

(USA–United States of America, UK-United Kingdom)

From the above table, it seems that only United States of America and United Kingdom have produced more than 100 publications in the initial period and the remaining countries have contributed only with single and two digit publications. There seems a large quantity of research outputs from United States of America, China and India in recent years when compared with other Nations contributions in the top ten categories. **Table. 1.** Further reveals that only United States of America and China have crossed at least once, the four digit mark in the yearly publications on Artificial Intelligence throughout the study period.

Tran et al. (2019) has published a research work on a global network of authors by using the content analysis of related scientific literature with the following keywords of major techniques, Machine learning, including Robotic, Artificial intelligence, Artificial neural network, Natural language process, and their most frequent applications in Clinical Prediction and Treatment.

Indian Contribution to Artificial Intelligence Literature (1986-2015)

India has contributed 2676 (4.00%) to the Global Artificial Intelligence literature during the study period (1986-2015). The analysis has been limited to publications indexed in Scopus database only. India is ranked 4th among the major contributors in Artificial Intelligence.

Yearly Distribution of Indian Contribution to Artificial Intelligence Literature

The yearly distributions of publications were analyzed with Ratio of Growth (RoG) and CAGR (Compound Annual Growth Rate) and are mentioned in **Table. 2 and Figures. 1-3.** From the **Table. 2** it is observed that the productivity by Indian researchers shows single and double digit publications from the beginning of the study period till 2009 and the first three digit publications reported in the year 2010 with 225 (8.41%) research outputs. The publication trend dips in the next two consequent years with 111 (4.15%) and 114 (4.26%) publications in 2011 and 2012 respectively. Then the publication trend shows rapid increase at the end of the study period with 467 (17.45%) publications in 2014 and with 907 (33.89%) publications in 2015 respectively. The **figure 4.2** illustrates the cumulative publications of the literature and shows linear growth during the study period. The ratio of growth of publications (RoG) ranged between 0.45 and 3.69 during the study period and reported very low in the year 1991 with 0.45 and high in the year 2010 with 3.69 and figure 4.30 shows the Ratio of Growth of literature during the

study period which shows an exponential growth rate. The Compound Annual Growth Rate (CAGR) ranged between 0.13 and 0.25. The figure 1 shows the CAGR on yearly distribution and shows a parabolic trend over the period. Niu et al. (2016) have reported that the growth of the research outputs has been increased in artificial intelligence research and has exploded since the 1990s, along with increasing collaboration, reference, and citations.

Table. 2. Yearly Distribution of Indian Contribution

S.No.	Year	TP	%	Cum	cum %	RoG	CAGR
1	1986	8	0.30	8	0.30		0.16
2	1987	8	0.30	16	0.60	1.00	0.16
3	1988	23	0.86	39	1.46	2.88	0.13
4	1989	19	0.71	58	2.17	0.83	0.14
5	1990	11	0.41	69	2.58	0.58	0.16
6	1991	5	0.19	74	2.77	0.45	0.20
7	1992	4	0.15	78	2.91	0.80	0.21
8	1993	9	0.34	87	3.25	2.25	0.19
9	1994	6	0.22	93	3.48	0.67	0.21
10	1995	14	0.52	107	4.00	2.33	0.18
11	1996	25	0.93	132	4.93	1.79	0.17
12	1997	14	0.52	146	5.46	0.56	0.20
13	1998	7	0.26	153	5.72	0.50	0.24
14	1999	14	0.52	167	6.24	2.00	0.21
15	2000	14	0.52	181	6.76	1.00	0.22
16	2001	13	0.49	194	7.25	0.93	0.24
17	2002	12	0.45	206	7.70	0.92	0.25
18	2003	20	0.75	226	8.45	1.67	0.24
19	2004	43	1.61	269	10.05	2.15	0.21
20	2005	54	2.02	323	12.07	1.26	0.20
21	2006	67	2.50	390	14.57	1.24	0.20
22	2007	63	2.35	453	16.93	0.94	0.22
23	2008	75	2.80	528	19.73	1.19	0.22
24	2009	61	2.28	589	22.01	0.81	0.25
25	2010	225	8.41	814	30.42	3.69	0.17
26	2011	111	4.15	925	34.57	0.49	0.24
27	2012	114	4.26	1039	38.83	1.03	0.25
28	2013	263	9.83	1302	48.65	2.31	0.20
29	2014	467	17.45	1769	66.11	1.78	0.16
30	2015	907	33.89	2676	100.00	1.94	0.10
		2676	100.00				

(RoG- Ratio of Growth, CAGR – compound Annual Growth Rate)

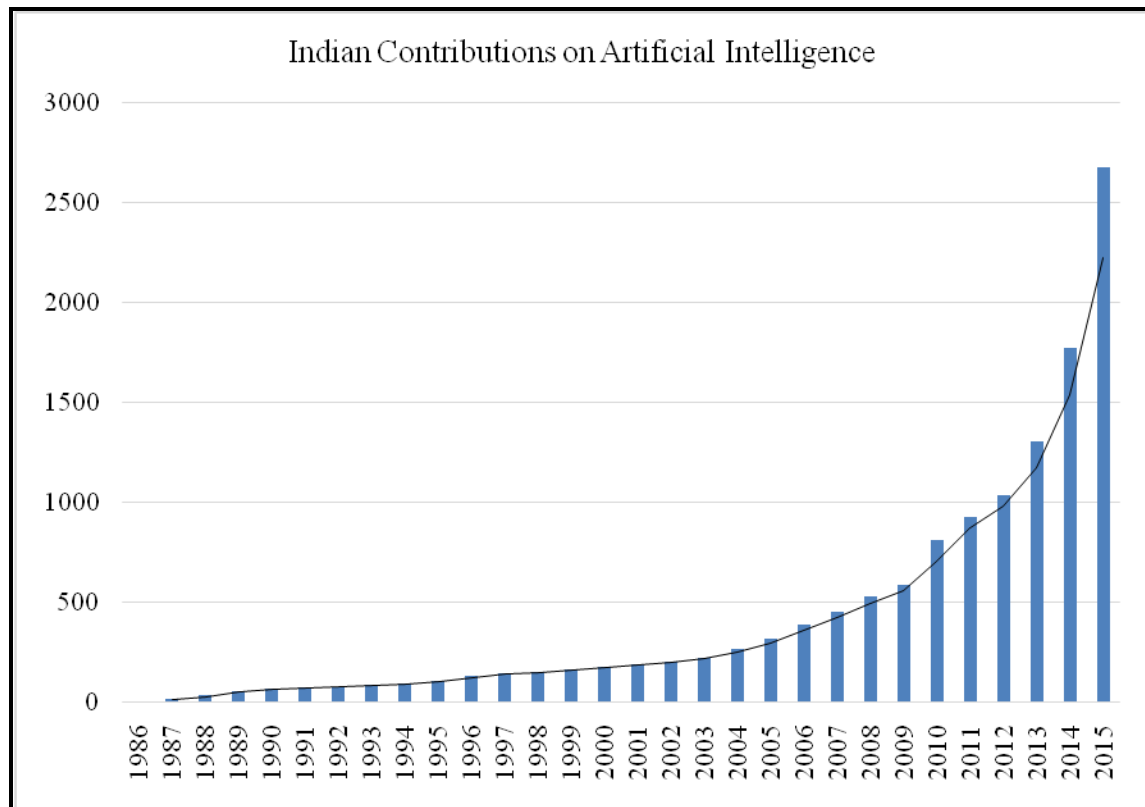


Figure 1. Yearly Distribution of Indian Contribution to Artificial Intelligence Literature

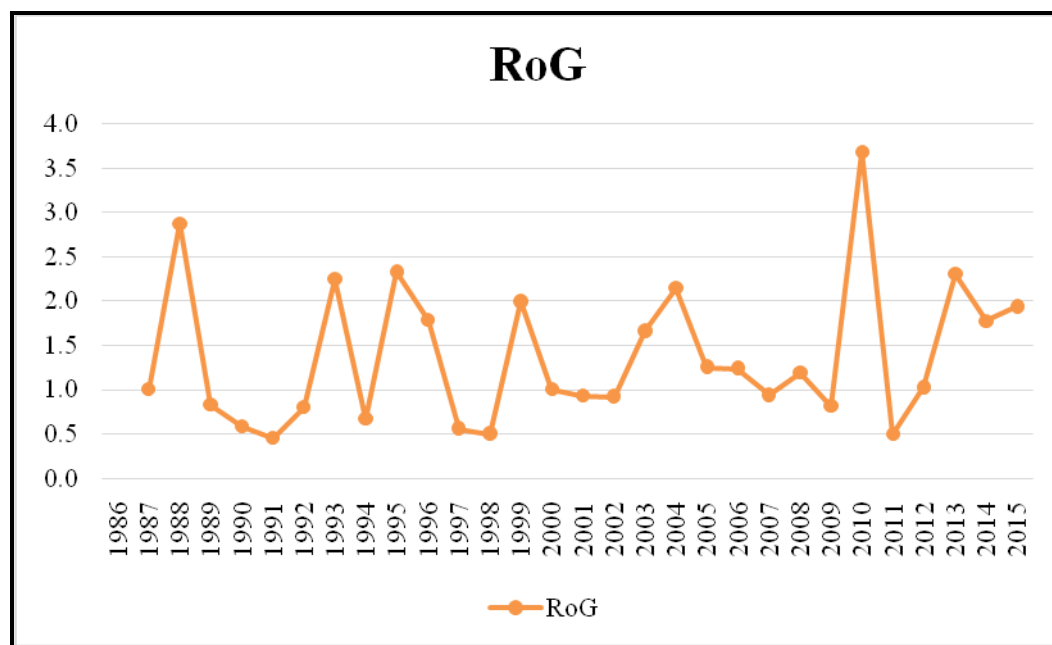


Figure 2. Indian Contribution Ratio of Growth

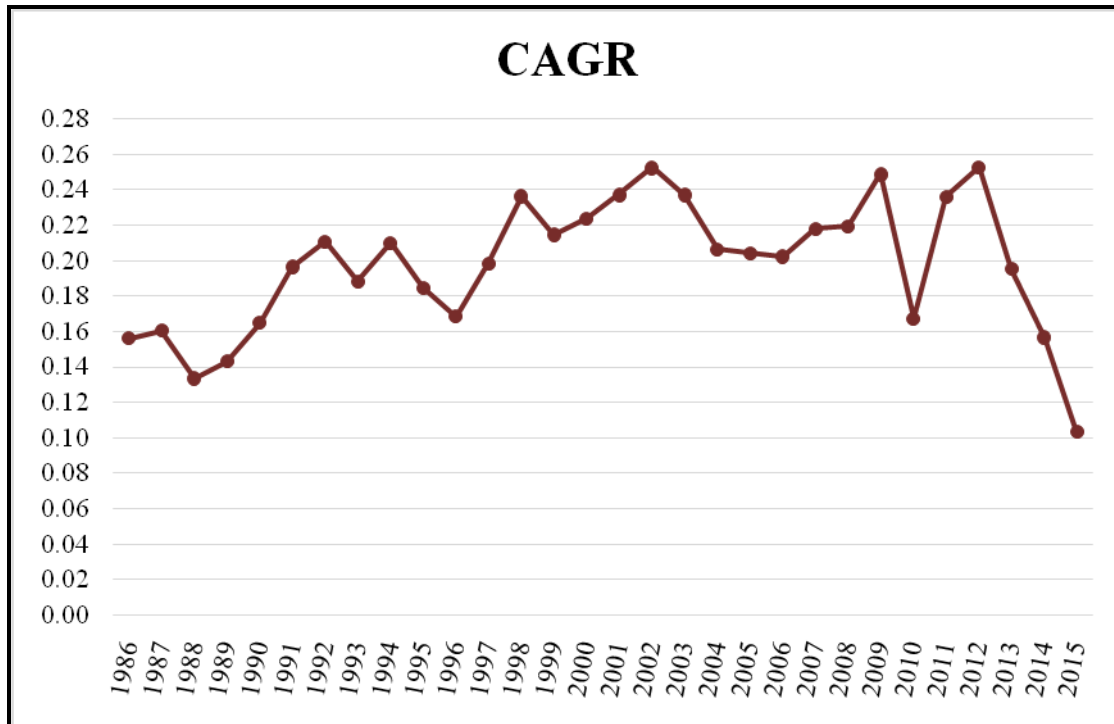


Figure 3. Indian Contribution compound Annual Growth Rate

Comparison on India Vs World Research Outputs on Artificial Intelligence Literature

A comparative study has been done on Indian publications with World literature outputs on Artificial Intelligence during the study period and the same has been depicted in the **Table. 3**. The above table shows that in the year 2010, the Indian Contribution to the Artificial Intelligence literature crossed 200 publications whereas at the same time the global publication has crossed 2786 publications. The Ratio of Growth (RoG) for Indian Contribution was ranged between 0.45 and 2.88 whereas it was 0.43 and 2.07 for the global publications during the study period. In recent years the Ratio of Growth ranged between 0.49 and 2.31 for the Indian contribution and it was 0.43 and 1.34 for the global publications shows that the growth ratio of Indian publications was slightly above the global research outputs.

Osareh and Mostafavi, (2011) have examined the validity of Lotka and Pao's laws with authorship distribution of "Computer Science" and "Artificial Intelligence" fields using Web of Science (WoS) during 1986 to 2009 and comparing the results of examinations.

Table. 3. Comparative Study on Yearly Distribution with Ratio of Growth

Year	India TP	%	cum.	Cum. %	RoG	Global TP	%	Cum.	Cum. %	RoG
1986	8	0.30	15	0.56	0.00	2246	3.36	2246	3.36	1.00
1987	8	0.30	29	1.08	1.00	2353	3.52	4599	6.88	1.05
1988	23	0.86	51	1.91	2.88	2230	3.34	6829	10.21	0.95
1989	19	0.71	88	3.29	0.83	2352	3.52	9181	13.73	1.05
1990	11	0.41	112	4.19	0.58	1219	1.82	10400	15.56	0.52
1991	5	0.19	137	5.12	0.45	918	1.37	11318	16.93	0.75
1992	4	0.15	161	6.02	0.80	905	1.35	12223	18.28	0.99
1993	9	0.34	204	7.62	2.25	1085	1.62	13308	19.90	1.20
1994	6	0.22	260	9.72	0.67	1252	1.87	14560	21.78	1.15
1995	14	0.52	337	12.59	2.33	1082	1.62	15642	23.40	0.86
1996	25	0.93	451	16.85	1.79	1092	1.63	16734	25.03	1.01
1997	14	0.52	556	20.78	0.56	1204	1.80	17938	26.83	1.10
1998	7	0.26	635	23.73	0.50	1130	1.69	19068	28.52	0.94
1999	14	0.52	696	26.01	2.00	1150	1.72	20218	30.24	1.02
2000	14	0.52	807	30.16	1.00	1193	1.78	21411	32.02	1.04
2001	13	0.49	876	32.74	0.93	1040	1.56	22451	33.58	0.87
2002	12	0.45	958	35.80	0.92	1023	1.53	23474	35.11	0.98
2003	20	0.75	1045	39.05	1.67	1305	1.95	24779	37.06	1.28
2004	43	1.61	1163	43.46	2.15	2699	4.04	27478	41.10	2.07
2005	54	2.02	1276	47.68	1.26	2824	4.22	30302	45.32	1.05
2006	67	2.50	1374	51.35	1.24	3283	4.91	33585	50.23	1.16
2007	63	2.35	1538	57.47	0.94	3877	5.80	37462	56.03	1.18
2008	75	2.80	1672	62.48	1.19	5198	7.77	42660	63.81	1.34
2009	61	2.28	1829	68.35	0.81	2227	3.33	44887	67.14	0.43
2010	225	8.41	1981	74.03	3.69	2786	4.17	47673	71.30	1.25
2011	111	4.15	2167	80.98	0.49	2452	3.67	50125	74.97	0.88
2012	114	4.26	2324	86.85	1.03	3330	4.98	53455	79.95	1.36
2013	263	9.83	2539	94.88	2.31	3294	4.93	56749	84.88	0.99
2014	467	17.45	2786	104.11	1.78	4368	6.53	61117	91.41	1.33
2015	907	33.89	3062	114.42	1.94	5741	8.59	66858	100.00	1.31
	2676	100				66858	100			

(TP – Total Publications, Cum. – Cumulative, Cum. % - Cumulative Percentage, RoG- Ratio of Growth)

Citation Analysis of Indian Contributions

The study examined the citation Analysis of Indian contributions during the study period and the analyses were presented in the **table 4**. The above table shows that the Indian Contributions received 7559 citations for its 808 cited papers out of the total 2676 publications at an average of 9.36 citations per paper.

Table. 4. Citation Analysis of Indian Contributions

S.No.	Year	TNP	TNCP	TC	CPP	GoR
1	1986	8	0	0	0.00	0
2	1987	8	3	6	0.75	3
3	1988	23	8	16	0.70	11
4	1989	19	8	26	1.37	19
5	1990	11	3	3	0.27	22
6	1991	5	3	65	13.00	25
7	1992	4	2	6	1.50	27
8	1993	9	5	16	1.78	32
9	1994	6	1	70	11.67	33
10	1995	14	8	20	1.43	41
11	1996	25	15	263	10.52	56
12	1997	14	9	64	4.57	65
13	1998	7	5	37	5.29	70
14	1999	14	6	186	13.29	76
15	2000	14	9	152	10.86	85
16	2001	13	10	110	8.46	95
17	2002	12	8	251	20.92	103
18	2003	20	9	20	1.00	112
19	2004	43	21	451	10.49	133
20	2005	54	37	628	11.63	170
21	2006	67	39	643	9.60	209
22	2007	63	36	773	12.27	245
23	2008	75	45	611	8.15	290
24	2009	61	35	904	14.82	325
25	2010	225	55	424	1.88	380
26	2011	111	61	520	4.68	441
27	2012	114	55	367	3.22	496
28	2013	263	79	278	1.06	575
29	2014	467	122	419	0.90	697
30	2015	907	111	230	0.25	808
	Total	2676	808	7559		

(TP-Total Publications, TC-Total Citations, CPP- Citations per Paper, RoG- Ratio of Growth)

The CPP had lot of ups and downs during the study period. Even though there was some increase in number of citations in the second half of the study period due to increase in number of research outputs, there was no remarkable increase in terms of citations shows that India needs to publish more number of quality publications to compete with other leading nations in the area of study.

Niu et al. (2016) have found that only lower citation was reported before the 2000s, and after that, it is found to be increased as the number of published articles increase. Thus, the less research output limited the number of citations before the 2000s, and after that, the rule of citation does work.

Table. 5. Bibliographic Form of Indian Contribution

S.No.	Bibliographic Form	Total Publications	%	Cum.	Cum. %
1	Conference Paper	1844	68.91	6408	239.46
2	Article	798	29.82	8812	329.30
3	Review	25	0.93	8998	336.25
4	Book Chapter	4	0.15	9005	336.51
5	Editorial	2	0.07	9043	337.93
6	Others	2	0.07	9049	338.15
7	Note	1	0.04	9056	338.42
	Total	2676	100.00		

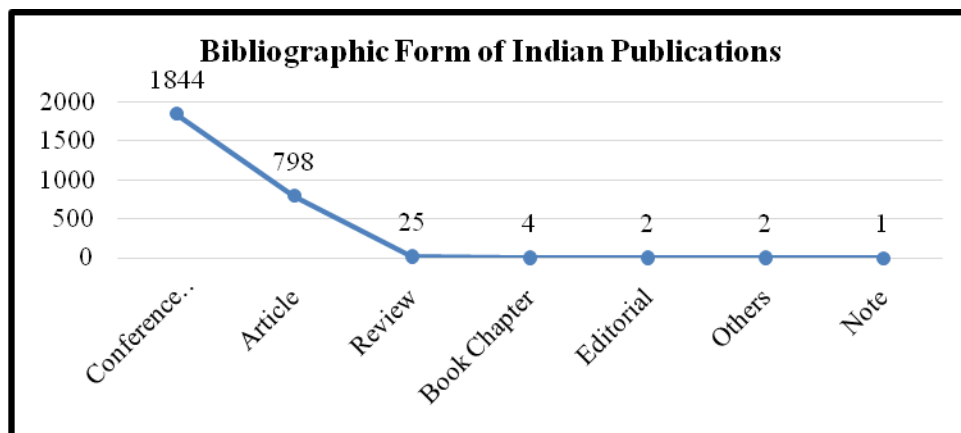


Figure. 4. Bibliographic Forms of Indian Contributions

The above table reveals that Indian researchers are not an exemption to their global counterparts in preferring conference papers ahead of journal articles to publish their research

outputs and published 68.91% of their research outputs in the form of Conference Papers followed by 29.82% by Journal Articles and 0.93% by Review articles. The bibliographic forms of Indian publications were shown in **figure 4**.

Top 10 Indian Authors

The data has been further analyzed on the top 10 Indian authors and presented in the table.6.

Table. 6. Top Ten Indian Authors Publications

S. No	Authors	TP	TCP	TC	CPP	CPP Rank	ACPP
1	Pal S.K.	16	15	746	49.73	1	49.73
2	Tiwari M.K.	16	15	222	14.80	7	14.80
3	Panigrahi B.K.	15	9	195	21.67	4	21.67
4	Karnan M.	10	3	3	1.00	9	1.00
5	Gupta H.O.	9	8	126	15.75	6	15.75
6	Krishnan N.	9	2	2	1.00	9	1.00
7	Mittal A.P.	9	3	8	2.67	8	2.67
8	Prade H.	9	2	41	20.50	5	20.50
9	Baskaran R.	8	5	147	29.40	3	29.40
10	Pal N.R.	8	8	336	42.00	2	42.00

(TP-Total Publications, CTP- Cited Total Publications, TC-Total Citations, ACPP-Average Citations per Paper)

From the above table it is observed that among the Indian authors Pal S.K., has contributed the highest number of 16 publications on Artificial Intelligence literature which yielded 746 citations with CPP of 49.73 citations per paper. Tiwari M.K., has published 16 papers and got 222 citations to his credit with 14.80 citations per paper. Panigrahi B. K., has contributed 15 publications and received 195 citations with 21.67 citations per paper.

Findings

Indian researchers shows single and double digits publications from the beginning of the study period till 2009 and the first three digit publications reported in the year 2010 with 225 (8.41%) research outputs. The publication trend dips in the next two consequent years with 111 (4.15%) and 114 (4.26%) publications in 2011 and 2012 respectively. Then the publication trend shows rapid increase at the end of the study period with 467 (17.45%) publications in 2014 and

with 907 (33.89%) publications in 2015 respectively. The figure 2 illustrates the cumulative publications of the literature and shows linear growth during the study period.

In the year 2010, the Indian Contribution to the Artificial Intelligence literature crossed 200 publications whereas at the same time the global publication has crossed 2786 publications. The Ratio of Growth (RoG) for Indian Contribution was ranged between 0.45 and 2.88 whereas it was 0.43 and 2.07 for the global publications during the study period. In recent years the Ratio of Growth ranged between 0.49 and 2.31 for the Indian contribution and it was 0.43 and 1.34 for the global publications shows that the growth ratio of Indian publications was slightly above the global research outputs. (**Table 3**).

The RGR and DT value shows that Indian contribution to the Artificial Intelligence literature grows faster than the global one.

The Indian Contributions received 7559 citations for its 808 cited papers out of the total 2676 publications at an average of 9.36 citations per paper. The CPP had lot of ups and downs during the study period. Even though there was some increase in number of citations in the second half of the study period due to increase in number of research outputs, there was no remarkable increase in terms of citations shows that India needs to publish more number of quality publications to compete with other leading nations in the area of study.

Indian researchers are not an exemption to their global counterparts in preferring conference papers ahead of journal articles to publish their research outputs and published 68.91% of their research outputs in the form of Conference Papers followed by 29.82% by Journal Articles and 0.93% by Review articles.

The top rank in terms of publications goes to Pal S.K., followed by Tiwari M.K., and Panigrahi B.K., In the total citations category the first rank goes to Pal S.K.,. Followed by Pal N.R., and Tiwari M.K., In terms of ACPP the first rank goes to Pal S.K followed by Pal N.R. and Baskaran R. (**Table. 6**).

Conclusion

It is interesting to note that more number of publications is being added to the Artificial Intelligence literature in recent years. Also, the research reveals that India is taking active part in research outputs in collaboration with developed countries. On one side the number of publications is on the rise and on the other side more number publications are not receiving even a single citation is a major concern for the researchers' community. There may be reasons for the

large quantum of uncited publications like poor quality of publications and majority of the publications may go unnoticed by the peers across the globe due to non availability of accessing sources. It is a welcoming note that India is placed fourth among the major contributors and its research organization.

References

- Chiarello, F., Steiner, M. T. A., Oliveira, E. B. D., Arce, J. E., & Ferreira, J. C. (2019). Artificial neural networks applied in forest biometrics and modeling: state of the art (January/2007 to July/2018). *Cerne*, 25(2), 140-155.
- Gagolewski, M., James, S., & Beliakov, G. (2019). Supervised learning to aggregate data with the Sugeno integral. *IEEE Transactions on Fuzzy Systems*, 27(4), 810-815.
- Gupta, B. M., & Dhawan, S. M. (2018). Artificial Intelligence Research in India: A Scientometric Assessment of Publications Output During 2007-16. *DESIDOC Journal of Library & Information Technology*, 38(6), 416-422.
- Hinojo-Lucena, F. J., Aznar-Díaz, I., Cáceres-Reche, M. P., & Romero-Rodríguez, J. M. (2019). Artificial Intelligence in higher education: A bibliometric study on its impact in the scientific literature. *Education Sciences*, 9(1), 51.
- Niu, J., Tang, W., Xu, F., Zhou, X., & Song, Y. (2016). Global research on artificial intelligence from 1990–2014: Spatially-explicit bibliometric analysis. *ISPRS International Journal of Geo-Information*, 5(5), 66.
- Osareh, F., & Mostafavi, E. (2011). A comparative survey of Lotka and Pao's laws conformity with the number of researchers and their articles in computer science and artificial intelligence fields in web of science (1986-2009). *Iranian Journal of Information processing and Management*, 26(4), 1349-1371.
- Shrivastava, R., & Mahajan, P. (2016). Artificial intelligence research in India: A scientometric analysis. *Science & Technology Libraries*, 35(2), 136-151.
- Shukla, A. K., Janmajaya, M., Abraham, A., & Muhuri, P. K. (2019). Engineering applications of artificial intelligence: A bibliometric analysis of 30 years (1988–2018). *Engineering Applications of Artificial Intelligence*, 85, 517-532.
- Tran, B. X., Nghiem, S., Sahin, O., Vu, T. M., Ha, G. H., Vu, G. T., & Ho, C. S. (2019). Modeling Research Topics for Artificial Intelligence Applications in Medicine: Latent

- Dirichlet Allocation Application Study. *Journal of medical Internet research*, 21(11), e15511.
- Tran, B. X., Vu, G. T., Ha, G. H., Vuong, Q. H., Ho, M. T., Vuong, T. T., ... & Latkin, C. A. (2019). Global evolution of research in artificial intelligence in health and medicine: A bibliometric study. *Journal of clinical medicine*, 8(3), 360.
- West, E., Mutasa, S., Zhu, Z., & Ha, R. (2019). Global Trend in Artificial Intelligence–Based Publications in Radiology From 2000 to 2018. *American Journal of Roentgenology*, 1-3.
- Zhang, X., Wang, X., Zhao, H., de Pablos, P. O., Sun, Y., & Xiong, H. (2019). An effectiveness analysis of altmetrics indices for different levels of artificial intelligence publications. *Scientometrics*, 119(3), 1311-1344.
- Zhou, X., Huang, L., Zhang, Y., & Yu, M. (2019). A hybrid approach to detecting technological recombination based on text mining and patent network analysis. *Scientometrics*, 121(2), 699-737.